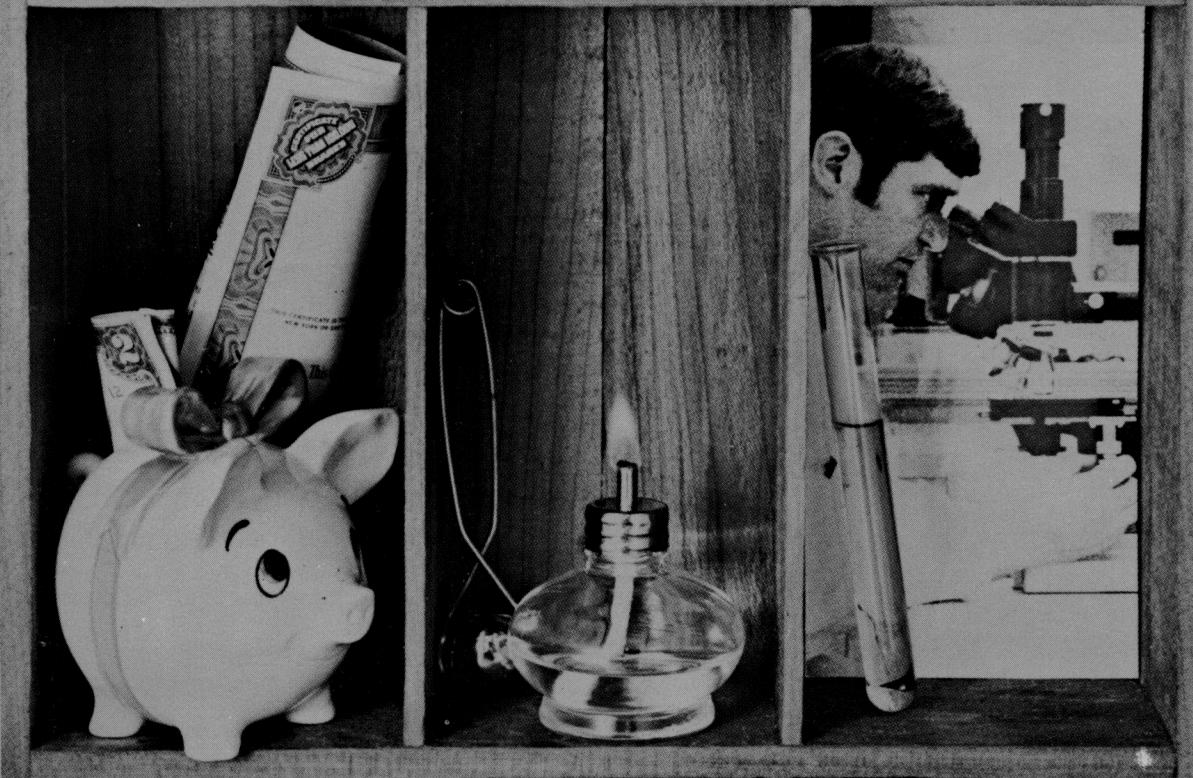


Hewlett-Packard  
**HP-19C/HP-29C  
SOLUTIONS**

**STUDENT ENGINEERING**



## INTRODUCTION

This HP-19C/HP-29C Solutions book was written to help you get the most from your calculator. The programs were chosen to provide useful calculations for many of the common problems encountered.

They will provide you with immediate capabilities in your everyday calculations and you will find them useful as guides to programming techniques for writing your own customized software. The comments on each program listing describe the approach used to reach the solution and help you follow the programmer's logic as you become an expert on your HP calculator.

You will find general information on how to key in and run programs under "A Word about Program Usage" in the Applications book you received with your calculator.

We hope that this Solutions book will be a valuable tool in your work and would appreciate your comments about it.

The program material contained herein is supplied without representation or warranty of any kind. Hewlett-Packard Company therefore assumes no responsibility and shall have no liability, consequential or otherwise, of any kind arising from the use of this program material or any part thereof.

## TABLE OF CONTENTS

RESISTIVE/REACTIVE CIRCUIT CALCULATIONS . . . . .	1
Performs resonance calculations.	
IMPEDANCE OF LADDER NETWORK . . . . .	5
Computes input impedance of arbitrary ladder network.	
STANDARD RESISTANCE VALUES. . . . .	8
Computes nearest standard value.	
EXPONENTIAL GROWTH OR DECAY . . . . .	11
Performs calculations for generalized growth and decay phenomena.	
EQUATIONS OF MOTION . . . . .	14
Calculates an interchangeable solution for object moving under constant acceleration.	
KINETIC ENERGY . . . . .	17
Calculates an interchangeable solution for weight (mass), velocity, and kinetic energy.	
RPM/TORQUE/POWER. . . . .	20
This program provides interchangeable solutions for RPM, torque, and power.	
BLACKBODY THERMAL RADIATION . . . . .	23
This program calculates the wavelength of maximum emissive power for a given temperature (or vice versa), and the emissive power (total, from $\lambda_1$ to $\lambda_2$ , or at $\lambda$ ).	
CONSERVATION OF ENERGY. . . . .	28
This program converts kinetic energy, potential energy, and pressure-volume work to energy, sums all the energy contributions, and converts the total to an equivalent velocity, height, pressure, or energy per unit mass.	
MOHR CIRCLE FOR STRESS . . . . .	32
This program calculates the principal stresses and their orientation given the state of stress on an element, and the maximum shear stress and its orientation.	
POLYNOMIAL EVALUATION (REAL OR COMPLEX) . . . . .	36
Evaluates polynomials with real or complex coefficients.	
SINE, COSINE AND EXPONENTIAL INTEGRALS. . . . .	39
Evaluates the sine, cosine and exponential integral by means of a series approximation.	

## RESISTIVE/REACTIVE CIRCUIT CALCULATIONS

This program performs resonance calculations for R-L-C circuits, calculates the reactance of inductive and capacitive branches, the equivalent value of series capacitors or parallel resistors and inductors, and performs power calculations for resistive branches using straightforward manipulations of the following equations:

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$X_C = \frac{1}{2\pi f C}$$

$$X_L = 2\pi f L$$

$$P = I^2 R = E^2 / R$$

$$\frac{A_1 A_2}{A_1 + A_2} = A_3$$

where

$f_r$  = resonant frequency in hertz

$L$  = inductance in henrys

$C$  = capacitance in farads

$X_C$  = capacitive reactance in  $\Omega$

$X_L$  = inductive reactance in  $\Omega$

$P$  = power in watts

$I$  = current in amps

$R$  = resistance in  $\Omega$

$E$  = voltage in volts

$A_1, A_2$  = the values of two parallel resistors in ohms, two parallel inductors in henrys, or two series capacitors in farads

$A_3$  = the resultant, equivalent resistance in ohms, inductance in henrys, or capacitance in farads

NOTE: Given a resistance or capacitance,  $A_1$ , the value of the circuit element required to produce a desired resultant resistance or capacitance may be calculated by entering  $A_1$  as a negative value.

### EXAMPLES:

1.  $C = .01\mu F$ ,  $L = 160\mu h$ .  
Calculate  $f_r$
2.  $L = 2.5h$ ,  $f_r = 60H_z$   
Calculate  $C$  and  $X_L$  at  $f_r$
3.  $E = 345v$ ,  $R = 1.25M\Omega$   
Calculate  $P$  and  $I$
4.  $R_1 = 120\Omega$ ,  $R_2 = 240\Omega$ 
  - a. Find the equivalent resistance of these two resistors in parallel,  $R_3$ .
  - b. Parallel  $R_3$  with  $50\Omega$ .
  - c. Find the resistance required for a resultant resistance of  $25\Omega$ .

SOLUTION:

ENG4  
 160.-06 ENT↑  
 0.01-06 GSB1  
 125.82+03 \*\*\*  $f_r$

60.0000 ENT↑  
 2.5000 GSB2  
 2.8145-06 \*\*\* C

60.0000 ENT↑  
 2.5000 GSB4  
 942.48+00 \*\*\*  $X_L$

345.0000 ENT↑  
 1.25+06 GSB5  
 95.220-03 \*\*\* P

1.25+06 GSB7  
 276.00-06 \*\*\* I

120.0000 ENT↑  
 240.0000 GSB9  
 80.000+00 \*\*\*  $R_3$

50.0000 GSB9  
 30.769+00 \*\*\* 4b  
 CHS  
 25.0000 GSB9 4c  
 133.33+00 \*\*\*

# User Instructions

# Program Listings

01	*LBL1		
02	X		
03	JX		
04	GT00		
05	*LBL2		
06	X <sup>2</sup> Y		
07	GSB0		
08	X <sup>2</sup>		
09	X <sup>2</sup> Y		
10	÷		
11	R/S	L or C	
12	*LBL3		
13	X		
14	GT00		
15	*LBL4		
16	X		
17	GSB0		
18	1/X		
19	R/S	X <sub>L</sub>	
20	*LBL5		
21	1/X		
22	*LBL6		
23	X <sup>2</sup> Y		
24	X <sup>2</sup>		
25	X	P	
26	R/S		
27	*LBL7		
28	1/X		
29	*LBL8		
30	X		
31	JX	I or E	
32	R/S		
33	*LBL0		
34	2		
35	X		
36	Pi		
37	X		
38	1/X	f <sub>r</sub> or X <sub>C</sub>	
39	RTN		
40	*LBL9		
41	X		
42	ENT↑		
43	ENT↑		
44	LSTX		
45	÷		
46	LSTX		
47	+	A <sub>3</sub> or A <sub>2</sub>	
48	÷		
49	R/S		

## REGISTERS

0	1	2	3	4	5
6	7	8	9	.0	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29

## IMPEDANCE OF A LADDER NETWORK

This program computes the input impedance of an arbitrary ladder network. Elements are added one at a time starting from the right. The first element must be in parallel.

Suppose we have a network whose input admittance is  $Y_{in}$ . Adding a shunt  $R$ ,  $L$ , or  $C$ , the input admittance becomes

$$Y_{new} = \begin{cases} Y_{in} + \left( \frac{1}{R} + j0 \right) \\ Y_{in} + \left( 0 - j \frac{1}{\omega L_p} \right) \\ Y_{in} + \left( 0 + j \omega C_p \right) \end{cases}$$

Adding a series  $R$ ,  $L$ , or  $C$ , we have

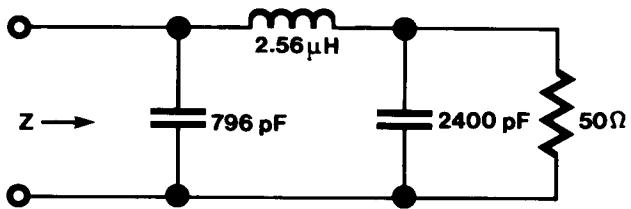
$$Y_{new} = \begin{cases} \left( \frac{1}{Y_{in}} + (R_s + j0) \right)^{-1} \\ \left( \frac{1}{Y_{in}} + (0 + j \omega L_s) \right)^{-1} \\ \left( \frac{1}{Y_{in}} + \left( 0 - j \frac{1}{\omega C_s} \right) \right)^{-1} \end{cases}$$

The program converts this admittance to an impedance for display.

NOTE: An erroneous entry may be corrected by entering the negative of the incorrect value.

### EXAMPLE:

$f = 4$  MHz



### SOLUTION:

```

FIX2
4.+06 GSB1
50.00 GSB3 |Zin|
50.00 *** X2Y
0.00 *** |Zin|
2400.-12 GSB5
15.74 *** |Zin|
X2Y
-71.66 *** |Zin|
2.56-06 GSB2
GSB5
49.65 *** |Zin|
X2Y
84.28 *** |Zin|
796.-12 GSB5
497.69 *** |Zin|
X2Y
8.98 *** |Zin|

```

## User Instructions

# Program Listings

7

01 *LBL1		f	50 GSB0	Convert $Y_{in} \rightarrow Z_{in}$
02 2			51 R↓	
03 Y			52 RCL6	
04 PI			53 +	
05 X	Clear flag		54 X#Y	Add admittances
06 CLRG			55 RCL7	or impedances
07 ST03			56 +	
08 R/S			57 X#Y	
09 *LBL0	Z↔Y		58 RCL0	
10 R↓			59 X#0?	
11 +P			60 GSB0	
12 1/X			61 R↓	Convert $Z \rightarrow Y$
13 X#Y			62 ST01	
14 CHS			63 X#Y	
15 X#Y			64 ST02	
16 →R			65 X#Y	
17 0			66 0	
18 RTN			67 GSB0	
19 *LBL2	R,C,L		68 ST00	Convert $Y \rightarrow Z$
20 ST00	Set flag (series)		69 R↓	Clear flag
21 R/S			70 +P	
22 *LBL3			71 R/S	
23 1/X				*** $ Z_{in}  / Z_{in}$
24 RCL0				
25 X=0?				
26 GT08	0,Y (parallel)			
27 0				
28 GT08				
29 *LBL4	0,Z (series)			
30 RCL3				
31 X				
32 1/X	X <sub>C</sub> or B <sub>L</sub>			
33 CHS				
34 0				
35 X#Y				
36 GT08				
37 *LBL5				
38 RCL3				
39 X	X <sub>L</sub> or B <sub>C</sub>			
40 0				
41 X#Y				
42 *LBL6				*** "Printx" may be inserted.
43 ST07				
44 X#Y				
45 ST06				
46 RCL2				
47 RCL1				
48 RCL0				
49 X#0?				

## REGISTERS

0	1	2	3	4	5
flag	Re[Y <sub>in</sub> ]	Im[Y <sub>in</sub> ]	$\omega = 2\pi f$		
used	used			.0	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29

## STANDARD RESISTANCE VALUES\*

For a given tolerance, a "step size" is computed which is used to determine two values, one below and one above the non-standard resistance. These are converted by a subroutine to standard values, and the geometric mean of the latter is calculated. If the given non-standard value is below the mean then the lower standard value is selected; otherwise the larger value is selected.

NOTE: Incorrect results will be obtained for tolerances other than 5%, 10%, or 20%.

REFERENCE: International Telephone and Telegraph Corp. Reference Data for Radio Engineers, fourth edition, p. 78.

EXAMPLES: Find the closest standard values for the following:

$$R_1 = 432\Omega$$

$$R_2 = 114 \text{ K}\Omega$$

$$R_3 = 3.5 \text{ M}\Omega$$

SOLUTION:

	ENG4	
	5.0000 GSE1	5%
	432.0000 GSE2	
	430.00+00 ***	R <sub>1</sub>
	114.+03 GSE2	
	110.00+03 ***	R <sub>2</sub>
	3.5+06 GSE2	
	3.6000+06 ***	R <sub>3</sub>
	10.0000 GSE1	10%
	432.0000 GSE2	
	470.00+00 ***	R <sub>1</sub>
	114.+03 GSE2	
	120.00+03 ***	R <sub>2</sub>
	3.5+06 GSE2	
	3.3000+06 ***	R <sub>3</sub>
	20.0000 GSE1	20%
	432.0000 GSE2	
	470.00+00 ***	R <sub>1</sub>
	114.+03 GSE2	
	100.00+03 ***	R <sub>2</sub>
	3.5+06 GSE2	
	3.3000+06 ***	R <sub>3</sub>

\* Adapted from HP-65 Users' Library program #00915A by Jacob Jacobs.

# User Instructions

# Program Listings

01 *LBL1		50 X	10 EXP R7
02 1		51 R/S	*** R
03 2		52 *LBL8	
04 0		53 .	Finds standard R
05 ÷		54 5	value from multiple
06 10 <sup>x</sup>		55 +	of step size
07 ST02	10 to 1/120	56 INT	Round up
08 R/S		57 ST06	
09 *LBL2		58 2	
10 LOG		59 6	
11 ENT↑		60 X>Y?	
12 INT		61 GT06	
13 ST04		62 4	
14 -		63 7	
15 1		64 RCL6	
16 +		65 X>Y?	
17 10 <sup>x</sup>		66 GT03	26<R<47 then add 1
18 ST03		67 1	
19 1		68 +	
20 ST-4		69 RTN	
21 1		70 *LBL3	
22 0		71 8	
23 ST05		72 3	
24 *LBL0		73 RCL6	
25 RCL3		74 X≠Y?	
26 RCL5		75 RTN	
27 X>Y?	This step >	76 8	
28 GT09	Normal R?	77 2	
29 RCL2		78 RTN	
30 X		79 *LBL7	
31 ST05		80 RCL6	
32 GT00		81 ST07	
33 *LBL9		82 RTN	
34 GSB8		83 *LBL6	
35 ST07	This step	84 RCL6	
36 RCL5		85 RTN	
37 RCL2		86 R/S	
38 ÷			
39 GSB8			
40 ST06	Last step		*** "Printx" may be inserted before "R/S".
41 RCL7			
42 X			
43 JX	✓(This step)*(Last		
44 RCL3	step)		
45 X≤Y?			
46 GSB7			
47 RCL7			
48 RCL4			
49 10 <sup>x</sup>			

## REGISTERS

0	1	2 Step size	3 Normal R	4 Exp of R	5 This step
6 Temp	7 Temp	8	9	.0	.1
.2	.3	.4	.5	.16	.17
18	19	20	21	22	23
24	25	26	27	28	29

## EXPONENTIAL GROWTH OR DECAY

Many growth or decay phenomena encountered in science and engineering obey an exponential law of the general form:

$$x_t = x_{ss} - (x_{ss} - x_0) e^{-\frac{t}{\tau}}$$

where:

$x_t$  = Value at any time,  $t$ , (i.e., the instantaneous value)

$x_{ss}$  = Steady state value (i.e., at  $t = \infty$ )

$x_0$  = Initial value (i.e., at  $t = 0$ )

$t$  = Elapsed time (time after  $t = 0$ )

$\tau$  = Exponential time-constant for specific phenomena

This program provides interchangeable solutions for any one of the four variables  $x_t$ ,  $x_{ss}$ ,  $x_0$  or  $t$  provided three variables and  $\tau$  are known.

### EXAMPLE 1:

Given a  $5\mu F$  capacitor in series with a 1 megohm resistor. 1.5 seconds after the circuit is completed 125 volts are measured across R. To what voltage was the capacitor originally charged?

### Note:

$\tau$  = the RC time-constant, and the voltage at  $t = \infty$  is zero

### SOLUTION:

```
5.-06 ENT↑
1.+06 x
ST04 τ = time-constant
125.00 ST01 v
0.00 ST02 Xss
1.50 ST03 time
GSB0
168.73 *** volts
```

### EXAMPLE 2:

A cobalt 60 source (half-life = 5.26 years) had an activity of 3.54 curies when purchased 8.5 years ago. What is its present activity?

### Note:

Activity at  $t = \infty$  will be zero,  
 $\tau = \text{half-life}/\text{LN}2$

### SOLUTION:

```
5.26 ENT↑
2.00 LN
÷
ST04 τ
3.54 ST00 X0
0.00 ST02 Xss
8.50 ST03 t
GSB1
1.15 *** curies
```

# User Instructions

# Program Listings

13

01 #LBL1	$X_t$			
02 RCL0				
03 RCL2				
04 -				
05 GSB5				
06 ÷				
07 RCL2				
08 +				
09 R/S	***			
10 #LBL2	$X_{SS}$			
11 GSB5				
12 ENT↑				
13 ENT↑				
14 RCL1				
15 x				
16 RCL0				
17 -				
18 X#Y				
19 1				
20 -				
21 ÷				
22 R/S	***			
23 #LBL0	$X_0$			
24 GSB5				
25 RCL1				
26 RCL2				
27 -				
28 x				
29 RCL2				
30 +				
31 R/S	***			
32 #LBL3	t			
33 RCL0				
34 RCL2				
35 -				
36 RCL1				
37 RCL2				
38 -				
39 ÷				
40 LN				
41 RCL4				
42 x				
43 R/S	***			
44 #LBL5	$e^{-t/\tau}$			
45 RCL3				
46 RCL4				
47 ÷				
48 e <sup>x</sup>				
49 RTN				
50 R/S				

\*\*\* "Printx" may be inserted before "R/S".

## REGISTERS

0	$X_0$	1	$X_t$	2	$X_{SS}$	3	t	4	5
6	$\tau$	7		8		9		.0	.1
.2		.3		.4		.5		16	17
18		19		20		21		22	23
24		25		26		27		28	29

## EQUATIONS OF MOTION

This program calculates an interchangeable solution among the variables: displacement, acceleration, initial velocity, and time or final velocity for an object that undergoes constant acceleration. The motion must be linear.

### EQUATIONS:

$$\text{Final velocity } v = \sqrt{v_0^2 + 2ax}$$

$$\text{Initial velocity } v_0 = \sqrt{v^2 - 2ax}$$

$$\text{Displacement } x = \frac{v^2 - v_0^2}{2a}$$

$$\text{Acceleration } a = \frac{v^2 - v_0^2}{2x}$$

$$\text{Displacement } x = v_0 t + \frac{1}{2} a t^2$$

$$\text{Initial velocity } v_0 = \frac{x}{t} - \frac{1}{2} a t$$

$$\text{Acceleration } a = \frac{x - v_0 t}{\frac{1}{2} t^2}$$

$$\text{Time } t = \frac{\sqrt{v_0^2 + 2ax} - v_0}{a}$$

velocity and acceleration are in opposite directions, one should be positive and the other negative.

All equations assume initial displacement,  $x_0$ , equals zero.

### EXAMPLE 1:

An automobile accelerates for 4 seconds from a speed of 35 mph and covers a distance of 264 feet. Assuming constant acceleration, what is the acceleration in  $\text{ft/sec}^2$ ? ( $7.33 \text{ ft/sec}^2$ ) If the acceleration continues to be constant, what distance is covered in the next second? (84.33 ft)

### SOLUTION:

264.00	ST01	x
35.00	ENT1	
5280.00		x
3600.00		÷
	ST02	$v_0$
4.00	ST03	t
	GSB4	
7.33	***	a
	5.00	ST03 t + 1 sec
		GSB1
348.33	***	x at t + 1 sec
264.00	-	x at t
84.33	***	x(t+1) - x(t)

### REMARKS:

Any consistent set of units may be used.

Displacement, acceleration, and velocity should be considered signed (vector) quantities. For example, if initial

EXAMPLE 2:

An airplane's take off velocity is 125 mph. Assume a constant acceleration of  $15 \text{ ft/sec}^2$ . How much runway length in feet will be used from start to take-off? (1120.37 ft.) How long will it take for the plane to reach take-off velocity? (12.22 sec)

SOLUTION:

```

0.00 STO2 v0
15.00 STO4
125.00 ENT†
5280.00 x
3600.00 ÷
STO5 v
GSB7
1120.37 ** x
GSB3
12.22 *** t

```

15

# User Instructions

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	Key in the program			
2.	Store variables			
	displacement	x	STO 1	x
	initial velocity	v <sub>0</sub>	STO 2	v <sub>0</sub>
	time	t	STO 3	t
	acceleration	a	STO 4	a
	final velocity	v	STO 5	v
	(store appropriate unknowns)			
3.	To calculate:			
	A. Displacement(a, v <sub>0</sub> and t or v known)			
	if t is known		GSB 1	x
	if v is known		GSB 7	x
	B. Initial Velocity (a, x, and t or v known)			
	if t is known		GSB 2	v <sub>0</sub>
	if v is known		GSB 6	v <sub>0</sub>
	C. Acceleration (v <sub>0</sub> , x and t or v known)			
	if t is known		GSB 4	a
	if v is known		GSB 8	a
	D. Time (v <sub>0</sub> , x and a known)		GSB 3	t
	E. Final Velocity (v <sub>0</sub> , x and a known)		GSB 5	v
4.	For a new case go to step 2			

# Program Listings

		x (t known)		
01	*LBL1		51	ST05
02	RCL2		52	RTN
03	RCL4		53	*LBL9
04	2		54	RCL4
05	÷		55	RCL1
06	RCL3		56	x
07	x		57	x
08	+		58	+
09	RCL3		59	fx
10	x		60	RTN
11	ST01	***	61	*LBL6
12	R/S		62	RCL5
13	*LBL2	v <sub>0</sub> (t known)	63	x <sup>2</sup>
14	RCL1		64	2
15	RCL3		65	CHS
16	÷		66	GSB9
17	LSTX		67	ST02
18	RCL4		68	R/S
19	x		69	*LBL7
20	2		70	4
21	÷		71	ST00
22	-		72	GSB0
23	ST02		73	ST01
24	R/S	***	74	R/S
25	*LBL4	a (t known)	75	*LBL8
26	RCL1		76	RCL5
27	RCL2		77	x <sup>2</sup>
28	RCL3		78	RCL2
29	x		79	x <sup>2</sup>
30	-		80	-
31	RCL3		81	RCL1
32	x <sup>2</sup>		82	2
33	2		83	x
34	÷		84	÷
35	÷		85	RTN
36	ST04		86	*LBL8
37	R/S	***	87	1
38	*LBL3	t	88	ST00
39	GSB5		89	GSB0
40	RCL2		90	ST04
41	-		91	R/S
42	RCL4			***
43	÷			
44	ST03			
45	R/S	***		*** "Printx" may be inserted before "R/S".
46	*LBL5	v		
47	RCL2			
48	x <sup>2</sup>			
49	2			
50	GSB9			

REGISTERS					
0 Used	1 x	2 v <sub>0</sub>	3 t	4 a	5 v
6	7	8	9	.0	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29

## KINETIC ENERGY

This program calculates an interchangeable solution among the variables weight (or mass), velocity, and kinetic energy, for an object moving at constant velocity. The program operates in either English or metric units. For metric units, any consistent set of units may be used; the quantity mass must be used. For English units, the energy must be in foot-pounds, the velocity in feet per second, and the quantity weight in pounds.

K.E. = Kinetic energy

W = Weight (lb)

m = Mass (kg, g)

v = Velocity

g = Acceleration due to gravity =  
32.17398 ft/sec<sup>2</sup>

### EQUATIONS:

English

$$\text{K.E.} = \frac{1}{2}W v^2$$

Metric

$$\text{K.E.} = \frac{1}{2}mv^2$$

$$1 \text{ ft-lb} = 1.98 \times 10^6 \text{ hp}$$

### EXAMPLE 1:

The slider of a slider-crank mechanism is used to punch holes in a slab of metal. It is found that the work required to punch a hole is 775 ft-lb. If the slider weighs 5 lb. 4 oz., how fast must it be moving when it strikes the metal? (97.46 ft/sec) What is the required work in horsepower? (3.91 x 10<sup>-4</sup> hp)

### SOLUTION:

69B2  
64.35 \*\*\* English Units

775.00 ST01  
5.00 ENT1  
4.00 ENT1  
16.00 =  
+  
5.25 \*\*\* W  
ST02

69B5  
97.46 \*\*\* v

69B3  
775.00 \*\*\* ft-lb  
R/S  
3.91-04 \*\*\* hp

### EXAMPLE 2:

An object weighing 4.8 kg is moving with constant velocity of 3.5 m/sec. Find its kinetic energy. (29.40 joules)

### SOLUTION:

69B1  
2.00 \*\*\* Metric Units

4.80 ST02  
3.50 ST03  
69B3  
29.40 \*\*\* K.E.

# User Instructions

# Program Listings

19

01 *LBL1	Metric		
02 2			
03 ST04			
04 R/S			
05 *LBL2	English		
06 6			
07 4			
08 .			
09 3			
10 4			
11 7			
12 9			
13 6			
14 ST04			
15 R/S			
16 *LBL3	K.E. Calc.		
17 RCL2			
18 RCL3			
19 ENT↑			
20 x			
21 x			
22 RCL4			
23 ÷			
24 ST01	***		
25 R/S			
26 RCL1			
27 1			
28 9			
29 8			
30 EEX			
31 4			
32 ÷	***		
33 R/S			
34 *LBL4	W(m) Calc.		
35 RCL1			
36 RCL4			
37 x			
38 RCL3			
39 ENT↑			
40 x			
41 ÷			
42 ST02	***		
43 R/S			
44 *LBL5	v Calc.		
45 RCL1			
46 RCL4			
47 x			
48 RCL2			
49 ÷			
50 JX			
51 ST03			
52 R/S	***		

## REGISTERS

0	1 K.E.	2 W(m)	3 v	4 2(met)	64.3(Eng)
6	7	8	9	.0	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29

## RPM/TORQUE/POWER

This program provides an interchangeable solution for RPM, torque, and power in both Systeme International (metric) and English units.

	SI	English
RPM	RPM	RPM
Torque	nt-m	ft-lb
Power	watts	hp

EQUATIONS:

$$\text{RPM} \times \text{Torque} = \text{Power}$$

$$1 \text{ hp} = 745.7 \text{ watts}$$

$$1 \text{ ft-lb} = 1.356 \text{ joules}$$

$$1 \text{ RPM} = \pi/30 \text{ radians/sec}$$

$$1 \text{ hp} = 550 \frac{\text{ft-lb}}{\text{sec}}$$

SOLUTIONS:

(1)

6500.00	ENT↑	GSB4
0.00	ENT↑	
11.00	GSB5	
8.89	***	Torque, ft-lb
	R/S	
12.05	***	Torque, nt-m

(2)

1600.00	ENT↑	GSB3
20.00	ENT↑	
0.90	÷	
0.00	GSB5	
3723.37	***	Power, watts
	R/S	
4.99	***	Power, hp

EXAMPLE 1:

Calculate the torque from an engine developing 11 hp at 6500 RPM. Find the SI equivalent.

EXAMPLE 2:

A generator is turning at 1600 RPM with a torque of 20 nt-m. If it is 90% efficient, what is the power input in both systems?

# User Instructions

# Program Listings

01 *LBL3	Set up for metric units	48 RCL3	** RPM	
02 3		49 ÷		
03 0		50 RCL7		
04 Pi		51 x		
05 ÷		52 R/S		
06 ST07		53 *LBL1		
07 7		54 RCL4		
08 4		55 RCL2		
09 5		56 ÷		
10 .		57 RCL7		
11 7		58 x		
12 ST05		59 R/S		
13 1		60 RCL6		
14 .		61 ÷		
15 3		62 R/S		
16 5		63 *LBL0		
17 6		64 RCL2		
18 ST06		65 RCL3		
19 RTN		66 x		
20 *LBL4	Set up for English units	67 RCL7	*** Torque	
21 GSB3		68 ÷		
22 1/X		69 R/S		
23 ST06		70 RCL5		
24 X#Y		71 ÷		
25 1/X		72 R/S		
26 ST05		** Power converted		
27 ÷		*** Power		
28 x		*** Power		
29 ST07		** Power converted		
30 RTN		*** Power		
31 *LBL5		** "Printx" may be inserted before "R/S".		
32 4		*** "Printx" may replace "R/S".		
33 ST00	Store variables			
34 R↓				
35 *LBL8				
36 ST01				
37 R↓				
38 DSZ				
39 GT08				
40 *LBL9				
41 X=0?				
42 GT01				
43 ISZ	Determine quantity to calculate			
44 R↓				
45 GT09				
46 *LBL2				
47 RCL4				

## REGISTERS

0	i	1 Used	2 RPM	3 Torque	4 Power	5 Used
6	Used	7 Used	8	9	.0	.1
.2		.3	.4	.5	16	17
18		19	20	21	22	23
24		25	26	27	28	29

## BLACK BODY THERMAL RADIATION

Bodies with finite temperatures emit thermal radiation. The higher the absolute temperature, the more thermal radiation emitted. Bodies which emit the maximum possible amount of energy at every wavelength for a specified temperature are said to be black bodies. While black bodies do not actually exist in nature, many surfaces may be assumed to be black for engineering considerations.

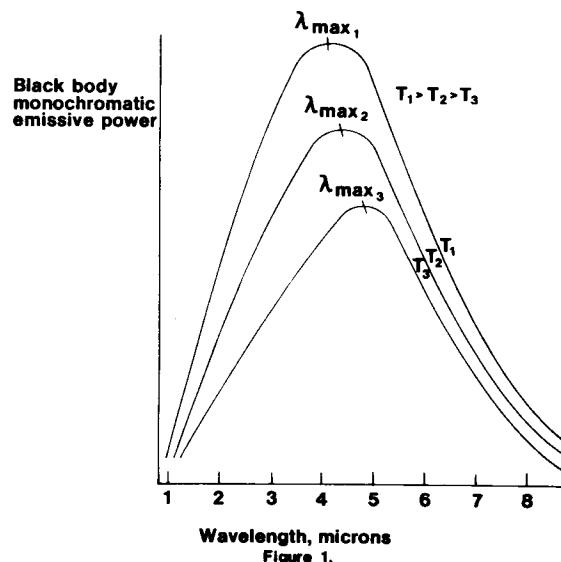


Figure 1 is a representation of black body thermal emission as a function of wavelength. Note that as temperature increases the area under the curves (total emissive power  $E_b(0-\infty)$ ) increases. Also note that the wavelength of maximum emissive power  $\lambda_{\max}$  shifts to the left as temperature increases.

This program can be used to calculate the wavelength of maximum emissive power for a given temperature, the temperature corresponding to a particular wavelength of maximum emissive power, the total emissive power for all wavelengths and the emissive power at

a particular wavelength. It can also be used to calculate the emissive power from zero to an arbitrary wavelength, the emissive power between two wavelengths or the total emissive power.

### EQUATIONS:

$$\lambda_{\max} T_{\lambda_{\max}} = c_3$$

$$E_b(0-\infty) = \sigma T^4$$

$$E_{b\lambda} = \frac{2\pi c_1}{\lambda^5 (e^{c_2/\lambda T} - 1)}$$

$$E_b(0-\lambda) = \int_0^\lambda E_{b\lambda} d\lambda$$

$$= 2\pi c_1 \sum_{k=1}^{\infty} -T/kc_2 e^{-\frac{k c_2}{T\lambda}} \left[ \left(\frac{1}{\lambda}\right)^3 + \right.$$

$$\left. + \frac{3T}{\lambda^2 k c_2} + \frac{6}{\lambda} \left(\frac{T}{k c_2}\right)^2 + 6 \left(\frac{T}{k c_2}\right)^3 \right]$$

$$E_{b(\lambda_1-\lambda_2)} = E_b(0-\lambda_2) - E_b(0-\lambda_1)$$

where

$\lambda_{\max}$  is the wavelength of maximum emissivity in microns;

$T$  is the absolute temperature in  $^{\circ}\text{R}$  or  $\text{K}$ ;

$E_b(0-\infty)$  is the total emissive power in Btu/hr-ft<sup>2</sup> or Watts/cm<sup>2</sup>;

$E_{b\lambda}$  is the emissive power at  $\lambda$  in Btu/hr-ft<sup>2</sup>- $\mu\text{m}$  or Watts/cm<sup>2</sup>- $\mu\text{m}$ ;

$E_{b(0-\lambda)}$  is the emissive power for wavelengths less than  $\lambda$  in Btu/hr-ft<sup>2</sup> or Watts/cm<sup>2</sup>;

$E_{b(\lambda_1-\lambda_2)}$  is the emissive power for wavelengths between  $\lambda_1$  and  $\lambda_2$  in Btu/hr-ft<sup>2</sup> or Watts/cm<sup>2</sup>.

$$c_1 = 1.8887982 \times 10^7 \text{ Btu-}\mu\text{m}^4/\text{hr-ft}^2 \\ = 5.9544 \times 10^3 \text{ W}\mu\text{m}^4/\text{cm}^2$$

$$c_2 = 2.58984 \times 10^4 \text{ }\mu\text{m-}^\circ\text{R} = \\ 1.4388 \times 10^4 \text{ }\mu\text{m-K}$$

$$c_3 = 5.216 \times 10^3 \text{ }\mu\text{m-}^\circ\text{R} = \\ 2.8978 \times 10^3 \text{ }\mu\text{m-K}$$

$$\sigma = 1.71312 \times 10^{-9} \text{ Btu/hr-ft}^2\text{-}^\circ\text{R}^4 = \\ 5.6693 \times 10^{-12} \text{ W/cm}^2\text{-K}^4$$

$$\sigma_{\text{exp}} = 1.731 \times 10^{-9} \text{ Btu/hr-ft}^2\text{-}^\circ\text{R}^4 \\ = 5.729 \times 10^{-12} \text{ W/cm}^2\text{-K}^4$$

#### REMARKS:

A minute or more may be required to obtain  $E_b(0-\lambda)$  or  $E_b(\lambda_1-\lambda_2)$  since the integration is numerical.

Sources differ on values for constants. This could yield small discrepancies between published tables and outputs.

#### REFERENCE:

Robert Siegel and John R. Howell,  
Thermal Radiation Heat Transfer, Vol. 1,  
National Aeronautics and Space Administration, 1968.

#### EXAMPLE 1:

What percentage of the radiant output of a lamp is in the visible range (0.4 to 0.7 microns) if the filament of the lamp is assumed to be a black body at 2400 K?

#### EXAMPLE 2:

If the human eye was designed to work most efficiently in sunlight and the visible spectrum runs from about 0.4 to 0.7 microns, what is the sun's temperature in degrees Rankine? Assume that the sun is a black body. Using the temperature calculated, find the fraction of the sun's total emissive power which falls in the visible range. Find the percentage of the sun's radiation which has a wavelength less than 0.4 microns.

#### SOLUTIONS:

1.

$$\begin{array}{l} 5954.40 \text{ ST01} \\ 14388.00 \text{ ST02} \\ 2897.80 \text{ ST03} \\ 5.6693-12 \text{ ST04} \\ 2400.00 \text{ ST05} \\ 0.40 \text{ ST06} \\ 0.70 \text{ ST07} \\ \text{GSB4} \\ 4.97 \text{ ***} \\ \text{GSB2} \quad E_b \text{ (0 to } \infty) \\ \vdots \\ 100.00 \text{ x} \\ 2.64 \text{ *** } (\%) \end{array} \left. \begin{array}{l} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \end{array} \right\} \text{S.I. constants}$$

2.

18887982.00	ST01	English constants
25898.40	ST02	
5216.00	ST03	
1.71312-09	ST04	
0.40	ENT↑	
0.70	+	
2.00	÷	
0.55	*** mean value	
RCL3		
÷		
1/X		
9483.64	*** T, (°R)	
ST05		
0.40	ST06	
0.70	ST07	
GSB4		
4678556.56	*** $E_b(0.4 \text{ to } 0.7)$	
GSB2		
13857578.83	*** $E_b(0 \text{ to } \infty)$	
÷		
100.00	X	
33.70	*** (%)	
0.40	ST06	
GSB1		
1168606.94	*** $E_b(0 \text{ to } 0.4)$	
GSB2		
÷		
100.00	X	
8.43	*** (%)	

# User Instructions

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Key in the program			
2	Store constants:			
2a	English units - (Btu, $\mu\text{m}$ , ft, $^{\circ}\text{R}$ )	18887982 25898.4 5216 $.171312 \times 10^{-8}$	STO 1 STO 2 STO 3 STO 4 STO 1 STO 2 STO 3 STO 4	
2b	SI units - (W, $\mu\text{m}$ , cm, $^{\circ}\text{K}$ )	5954.4 14388 2897.8 $5.6693 \times 10^{-12}$	STO 1 STO 2 STO 3 STO 4	
3	For experimental Stefan-Boltzmann constant instead of theoretical constant	1.0105	STO x 4	
4	To calculate $\lambda_{\text{max}} = f(T)$	$T(^{\circ}\text{R or k})$	RCL 3 $\div$	$\lambda_{\text{max}}(\mu\text{m})$
5	To calculate $T = f(\lambda)$ for which $\lambda$ is maximum	$\lambda(\mu\text{m})$	RCL 3 $\div$	$T(^{\circ}\text{R or k})$
6	To calculate total emissive power	$T^*$	STO 5 GSB 2	$E_b(0 \text{ to } \infty)$
7	To calculate emissive power at $\lambda$	$T^*$ $\lambda$	STO 5 STO 6 GSB 3	$E_b(\lambda)$
8	To calculate emissive power from 0 to $\lambda_1$	$T^*$ $\lambda_1$	STO 5 STO 6 GSB 1	$E_b(0 \text{ to } \lambda_1)$
9	To calculate emissive power from $\lambda_1$ to $\lambda_2$	$T^*$ $\lambda_1$ $\lambda_2$	STO 5 STO 6 STO 7	
	*any value of T stored previously is still	stored and need not be input again	GSB 4	$E_b(\lambda_1 \text{ to } \lambda_2)$

# Program Listings

01 *LBL1		50 X $\leq$ Y?	$\Delta \geq .001\%$
02 GSB9		51 ST00	yes, increment k
03 R/S		52 RCL9	
04 *LBL9		53 2	
05 0		54 x	
06 ST09		55 PI	
07 ST08		56 x	
08 *LBL0		57 RCL1	
09 RCL2		58 x	
10 RCL5		59 RTN	
11 $\div$		60 *LBL2	$E_b(0 \text{ to } \lambda)$
12 ST-8	-k c <sub>2</sub> /T	61 RCL5	
13 3		62 4	
14 RCL8		63 Y <sup>x</sup>	
15 $\div$		64 RCL4	
16 RCL6		65 x	
17 X <sup>2</sup>		66 R/S	*** $E_b(0 \text{ to } \infty)$
18 $\div$		67 *LBL3	
19 LSTX	$\lambda^2$	68 RCL1	
20 RCL6		69 2	
21 x		70 x	
22 1/X		71 PI	
23 -		72 x	
24 6		73 RCL6	
25 RCL6		74 5	
26 $\div$		75 Y <sup>x</sup>	
27 RCL8		76 $\div$	
28 X <sup>2</sup>		77 RCL2	
29 $\div$		78 RCL6	
30 -		79 $\div$	
31 6		80 RCL5	
32 RCL8		81 $\div$	*** $E_{b\lambda}$
33 3		82 e <sup>x</sup>	
34 Y <sup>x</sup>		83 1	
35 $\div$		84 -	
36 +		85 $\div$	
37 RCL8		86 R/S	*** $E_{b\lambda}$
38 RCL6		87 *LBL4	
39 $\div$		88 GSB9	
40 e <sup>x</sup>		89 ST.0	$E_b(0 \text{ to } \lambda_1)$
41 x		90 RCL7	
42 RCL8		91 ST06	$\lambda_2$
43 $\div$		92 GSB9	
44 ST+9	$\Delta$	93 RC.0	
45 RCL9		94 -	
46 $\div$		95 R/S	*** $E_{b(\lambda_1 \text{ to } \lambda_2)}$
47 EEX		***"Printx" may be inserted before "R/S"	
48 CHS		***"Printx" may be inserted before "R/S"	
49 5		***"Printx" may be inserted before "R/S"	

## REGISTERS

0	1 C <sub>1</sub>	2 C <sub>2</sub>	3 C <sub>3</sub>	4 σ	5 T
6 λ	7 λ <sub>2</sub>	8 -Kc <sub>2</sub> /T	9 sum	.0 used	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29

## CONSERVATION OF ENERGY

This program converts kinetic energy, potential energy, and pressure-volume work to energy. Energy is stored as a running total which may at any time be converted to an equivalent velocity, height, pressure, or energy per unit mass. The program is useful in fluid flow problems where velocity, elevation and pressure change along the path of flow.

### EQUATIONS:

$$\frac{v_1^2}{2} + gz_1 + \frac{P_1}{\rho} + \frac{E_1}{\dot{m}} =$$

$$\frac{v_2^2}{2} + gz_2 + \frac{P_2}{\rho} + \frac{E_2}{\dot{m}}$$

where:

$v$  is the fluid velocity;

$z$  is the height above a reference datum;

$P$  is the pressure;

$E$  is an energy term which could represent inputs of work or friction losses (negative value);

$g$  is the acceleration of gravity;

$\rho$  is the fluid density;

$\dot{m}$  is the mass flow rate (assumed to be unity);

subscripts 1 and 2 refer to upstream and downstream values respectively.

### NOTES:

Downstream values should be input as negatives. However, when an output is called for, the calculator displays the relative value with no regard to upstream or downstream location.

An error will result when the total energy sum stored in register 8 is negative and an attempt is made to calculate velocity.

### EXAMPLE 1:

A water tower is 100 feet high. What is the zero flow rate pressure at the base? The density of water is 62.4 lb/ft<sup>3</sup>.

If water is flowing out of the tower at a velocity of 10 ft/sec, what is the static pressure?

What is the maximum frictionless flow velocity which could be achieved with the 100 foot tower?

If 10000 pounds of water are pumped to the top of the tower every hour, at a velocity of 20 ft/sec, with a frictional pressure drop of 2 psi, how much power is needed at the pump?

### EXAMPLE 2:

An incompressible fluid ( $\rho = 735 \text{ kg/m}^3$ ) flows through the converging passage of Figure 1. At point 1 the velocity is 3 m/s and at point 2 the velocity is 15 m/s. The elevation difference between points 1 and 2 is 3.7 meters. Assuming frictionless flow, what is the static pressure difference between points 1 and 2?

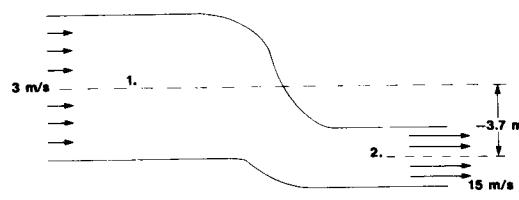


Figure 1.

EXAMPLE 3:

A reservoir's level is 25 meters above the discharge pond. Assuming 85% power generation efficiency, how much power can be generated with a flow rate of 20 m<sup>3</sup>/s?

$$\rho = 1000 \text{ kg/m}^3$$

SOLUTIONS:

(1) 25033.407 ST05  
       32.17 ST06  
       4632.48 ST07  
       62.40 GSB1  
       100.00 GSB3  
       GSB8  
       43.33 \*\*\* (psig)  
       -10.00 GSB2  
       GSB8  
       42.66 \*\*\* (psig)  
       62.40 GSB1  
       100.00 GSB3  
       GSB6  
       80.21 \*\*\* (ft/sec)  
       62.40 GSB1  
       20.00 GSB2  
       2.00 GSB4  
       100.00 GSB3  
       GSB9  
       0.14 \*\*\* (BTU/lb)  
       10000.00 x  
       1424.29 \*\*\* (BTU/hr)

(2) 1.00 ST05  
       ST07  
       9.80665 ST06  
       735.00 GSB1  
       3.00 GSB2  
       3.70 GSB3  
       -15.00 GSB2  
       GSB8  
       -52710.82 \*\*\* (Nt/m<sup>2</sup>)

(3) 1000.00 GSB1  
       25.00 GSB3  
       GSB9  
       245.17 \*\*\* (joule/kg)  
       0.85 x  
       208.39 \*\*\* (joule/kg)  
       20.00 ENT↑  
       1000.00 x (kg/s)  
       x  
       4167826.25 \*\*\* (watts)

# User Instructions

# Program Listings

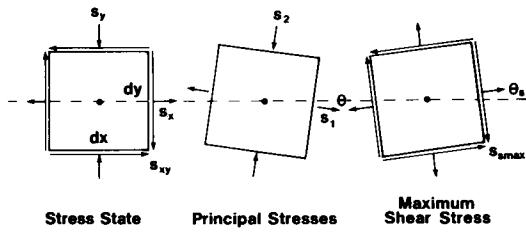
01 *LBL1						
02 ST04						
03 0	ρ					
04 ST08	Clear Σ E					
05 R/S						
06 *LBL2						
07 ENT↑						
08 ABS						
09 X						
10 2						
11 ÷	± v <sup>2</sup> /2					
12 GT05						
13 *LBL3						
14 RCL6						
15 X						
16 GT05	gz					
17 *LBL4						
18 RCL7						
19 X						
20 RCL4	ρ/ρ					
21 ÷	E					
22 *LBL5						
23 ST+8						
24 R/S						
25 *LBL6						
26 RCL8						
27 2						
28 X						
29 √X						
30 R/S	*** v					
31 *LBL7						
32 RCL8						
33 RCL6						
34 ÷						
35 R/S	*** z					
36 *LBL8						
37 RCL8						
38 RCL7						
39 ÷						
40 RCL4						
41 X						
42 R/S	*** p					
43 *LBL9						
44 RCL8						
45 RCL5						
46 ÷						
47 R/S	*** e					
*** "Printx" may be inserted before "R/S".						

## REGISTERS

0	1	2	3	4	ρ	5 Used
6 g	7 Used	8 Σ E	9	.0		.1
.2	.3	.4	.5	16		17
18	19	20	21	22		23
24	25	26	27	28		29

## MOHR CIRCLE FOR STRESS

Given the state of stress on an element, the principal stresses and their orientation can be found. The maximum shear stress and its orientation can also be found.

EQUATIONS:

$$s_{\text{max}} = \sqrt{\left(\frac{s_x - s_y}{2}\right)^2 + s_{xy}^2}$$

$$s_1 = \frac{s_x + s_y}{2} + s_{\text{max}}$$

$$s_2 = \frac{s_x + s_y}{2} - s_{\text{max}}$$

$$\theta = 1/2 \tan^{-1} \left( \frac{2s_{xy}}{s_x - s_y} \right)$$

$$\theta_s = 1/2 \tan^{-1} \left( -\frac{s_x - s_y}{2s_{xy}} \right)$$

where:

$s_{\text{max}}$  is the maximum shear stress;

$s_1$  and  $s_2$  are the principal normal stresses;

$\theta$  is the angle of rotation from the principal axis to the original axis;

$\theta_s$  is the angle of rotation from the axis of maximum shear stress to the original axis;

$s_x$  is the stress in the x direction;

$s_y$  is the stress in the y direction;

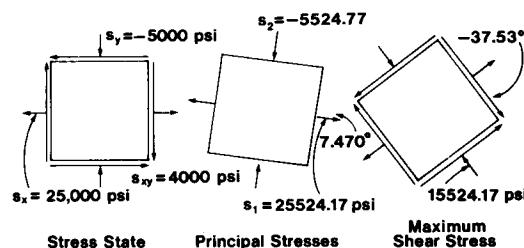
$s_{xy}$  is the shear stress on the element.

REFERENCE:

Spotts, M.F., Design of Machine Elements, Prentice-Hall, 1971.

EXAMPLE:

If  $s_x = 25000$  psi,  $s_y = -5000$  psi, and  $s_{xy} = 4000$  psi, compute the principal stresses and the maximum shear stress.



SOLUTION:

25000.00 ENT↑  
-5000.00 ENT↑  
4000.00 GSB1  
25524.17 \*\*\* R/S  $s_1$  (psi)  
-5524.17 \*\*\* R/S  $s_2$  (psi)  
7.47 \*\*\* R/S  $\theta$  (degrees)  
-37.53 \*\*\* R/S  $\theta_s$  (degrees)  
15524.17 \*\*\*  $s_{smax}$  (psi)

# User Instructions

# Program Listings

35

01 *LBL1					
02 ENT					
03 R↓					
04 ST03	$s_{xy} \ s_y \ s_x \ s_{xy}$				
05 R↓					
06 X#Y					
07 ST01	$s_x$				
08 X#Y	$s_y$				
09 ST+1					
10 -	$s_x - s_y$				
11 2					
12 ST÷1					
13 ÷					
14 ST04	$(s_x - s_y)/2$				
15 →P					
16 ST02	$s_{smax}$				
17 RCL1					
18 +					
19 R/S	** $s_1$				
20 X#Y	2·θ				
21 RCL1					
22 RCL2					
23 -					
24 R/S	** $s_2$				
25 X#Y					
26 2					
27 ÷					
28 R/S	** θ				
29 RCL4					
30 RCL3					
31 ÷					
32 CHS					
33 TAN <sup>-1</sup>					
34 2					
35 ÷					
36 R/S	** $\theta_s$		** "Printx" may replace "R/S".		
37 RCL2					
38 R/S	*** $s_{smax}$		*** "Printx" may be inserted before "R/S".		

## REGISTERS

0	1 $(s_x + s_y)/2$	2 $s_{smax}$	3 $s_{xy}$	4 $(s_x - s_y)/2$	5
6	7	8	9	.0	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29

## POLYNOMIAL EVALUATION--REAL OR COMPLEX

This program evaluates polynomials of the form:

$$f(x_0) = a_0 + a_1 x + \dots + a_n x^n$$

where the coefficients

$a_k, k=0, \dots, n$  ( $n \leq 28$ ) and  $x_0$  are real or the coefficients and  $x_0$  are complex of the form

$$a_k = \operatorname{Re}(a_k) + i \operatorname{Im}(a_k)$$

$$z_0 = \operatorname{Re}(z_0) + i \operatorname{Im}(z_0)$$

$$k = 0, 1, \dots, n$$

Example 1:

$$f(x) = 11 - 7x - 3x^2 + 5x^4 + x^5$$

$$\text{for } x_0 = 2.5$$

$$\text{for } x_0 = -5$$

Solution:

```

CLRG
11.00 GSB1
-7.00 R/S
-3.00 R/S
0.00 R/S
5.00 R/S
1.00 R/S
2.50 GSB2
267.72 *** f (2.5)
6.00 ST00
-5.00 GSB2
-29.00 *** f (-5)

```

Example 2:

$$f(x) = (5-7i) - 10x + (-2+i)x^2 + 18x^3 + (3+4i)x^4$$

$$\text{for } x_0 = 2 + i$$

Solution:

```

1.00 ENT↑
2.00 GSB3
4.00 ENT↑
3.00 GSB4
0.00 ENT↑
18.00 GSB4
1.00 ENT↑
-2.00 GSB4
0.00 ENT↑
-10.00 GSB4
-7.00 ENT↑
5.00 GSB5
-106.00 *** Re f(x_0)
R/S
220.00 *** Im f(x_0)

```

# User Instructions

01 *LBL1		50 *LBL9	Add real parts and
02 ISZ		51 X $\leftrightarrow$ Y	imaginary parts
03 ST01		52 R $\downarrow$	
04 R/S		53 +	
05 GT01		54 R $\downarrow$	
06 *LBL2		55 +	
07 ENT $\uparrow$		56 X $\leftrightarrow$ Y	
08 ENT $\uparrow$		57 R $\downarrow$	
09 ENT $\uparrow$		58 X $\leftrightarrow$ Y	
10 RCL1		59 RTN	
11 X	Multiply by $x_0$	60 R/S	
12 DSZ			
13 *LBL0			
14 RCL1			
15 +	Multiply by $x_0$		
16 X			
17 DSZ			
18 GT00			
19 X $\leftrightarrow$ Y			
20 $\div$	Divide by $x_0$		
21 R/S	*** $f(x_0)$		
22 *LBL3	Routines for		
23 $\rightarrow$ P	complex polynomials		
24 ST01	r		
25 X $\leftrightarrow$ Y			
26 ST02	0		
27 0			
28 ENT $\uparrow$	Prepare for LBL 9		
29 ENT $\uparrow$			
30 ENT $\uparrow$			
31 RTN			
32 *LBL4			
33 GSBS			
34 GT02			
35 *LBL5			
36 GSBS			
37 R/S	*** Re $f(x_0)$		
38 X $\leftrightarrow$ Y			
39 R/S	*** Im $f(x_0)$		
40 *LBL6	Multiply in polar		
41 $\rightarrow$ P	form		
42 RCL1			
43 X			
44 X $\leftrightarrow$ Y			
45 RCL2			
46 +			
47 X $\leftrightarrow$ Y			
48 $\rightarrow$ R			
49 RTN			

\*\*\* "Printx" may be inserted or used to replace "R/S".

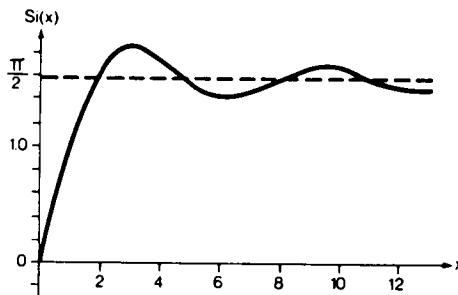
## SINE, COSINE, AND EXPONENTIAL INTEGRALS

Sine integral:

$$Si(x) = \int_0^x \frac{\sin t}{t} dt = \sum_{n=0}^{\infty} \frac{(-1)^n x^{2n+1}}{(2n+1)(2n+1)!}$$

where  $x$  is real.

This routine computes successive partial sums of the series, stops when two consecutive partial sums are equal, and displays the last partial sum as the answer.



Notes: When  $x$  is too large, computing a new term of the series might cause an overflow. In that case, display shows all 9's and the program stops.

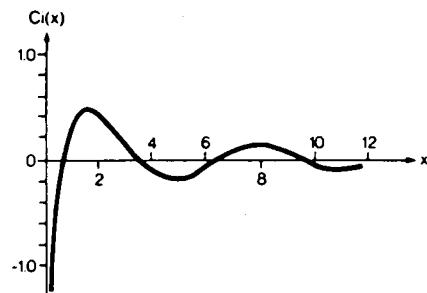
$$Si(-x) = -Si(x)$$

Cosine integral:

$$Ci(x) = \gamma + \ln x + \int_0^x \frac{\cos t - 1}{t} dt = \gamma + \ln x + \sum_{n=1}^{\infty} \frac{(-1)^n x^{2n}}{2n(2n)!}$$

where  $x > 0$ , and  $\gamma = 0.577215665$  is the Euler's constant.

This program computes successive partial sums of the series. When two consecutive partial sums are equal, the value is used as the sum of the series.



Notes: When  $x$  is too large, computing a new term of the series might cause an overflow. In that case, display shows all 9's and the program stops.

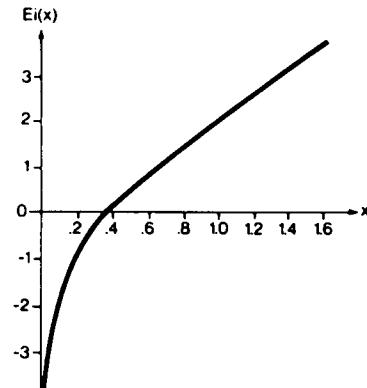
$$Ci(-x) = Ci(x) - i\pi \text{ for } x > 0.$$

Exponential integral:

$$Ei(x) = \int_{-\infty}^x \frac{e^t}{t} dt = \gamma + \ln x + \sum_{n=1}^{\infty} \frac{x^n}{n n!}$$

where  $x > 0$  and  $\gamma = 0.577215665$  is Euler's constant.

This program computes successive partial sums of the series. When two consecutive partial sums are equal, the value is used as the sum of the series.



Note: When  $x$  is too large, computing a new term of the series might cause an overflow. In that case, display shows all 9's and the program stops.

References: Handbook of Mathematical Functions, Abramowitz and Stegun, National Bureau of Standards, 1968.

Examples:

1. Si (.69)
2. Si (.98)
3. Ci (1.38)
4. Ci (5)
5. Ei (1.59)
6. Ei (.61)

Solutions:

0.577215665 ST. 0  
 0.69 GSB1  
 0.67 \*\*\*  
 0.98 GSB1  
 0.93 \*\*\*  
 1.38 GSB2  
 0.46 \*\*\*  
 5.00 GSB2  
 -0.19 \*\*\*  
 1.59 GSB3  
 3.57 \*\*\*  
 0.61 GSB3  
 0.80 \*\*\*

## User Instructions

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	Key in the program			
2.	Store $\alpha$	.577215665	STO . 0	$\alpha$
3.	For Sine Integral	x	GSB 1	Si(x)
	For Cosine Integral	x	GSB 2	Ci(x)
	For Exponential Integral	x	GSB 3	Ei(x)

01 *LBL1	Sine Integral routine	50 RC.0			
02 ST03		51 +			
03 X <sup>2</sup>		52 *LBL9			
04 CHS		53 RCL1			
05 ST01		54 RCL2			
06 1		55 1			
07 ST02		56 +			
08 RCL3		57 ST02			
09 *LBL0		58 -			
10 RCL1		59 RCL3			
11 RCL2		60 X			
12 1		61 ST03			
13 +		62 RCL2			
14 -		63 -			
15 LSTX		64 +			
16 1		65 X*Y?			
17 +		66 GT09			
18 ST02		67 R/S			*** Ei(x)
19 -					
20 RCL3					
21 X					
22 ST03					
23 RCL2					
24 -					
25 +					
26 X*Y?					
27 GT08					
28 R/S					
29 *LBL2	*** Si(x)/Ci(x)				
30 X <sup>2</sup>	Cosine Integral				
31 CHS	routine				
32 ST01					
33 1					
34 ST03					
35 0					
36 ST02					
37 LSTX					
38 LN					
39 RC.0					
40 +					
41 GT08					
42 *LBL3					
43 ST01					
44 1					
45 ST03					
46 0					
47 ST02					
48 RCL1					
49 LN	Exponential In-				
	tegral routine				
REGISTERS					
0	1 used	2 used	3 used	4	5
6	7	8	9	.0 used	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29

\*\*\* "Print X" may be used to replace "R/S".

In the Hewlett-Packard tradition of supporting HP programmable calculators with quality software, the following titles have been carefully selected to offer useful solutions to many of the most often encountered problems in your field of interest. These ready-made programs are provided with convenient instructions that will allow flexibility of use and efficient operation. We hope that these Solutions books will save your valuable time. They provide you with a tool that will multiply the power of your HP-19C or HP-29C many times over in the months or years ahead.

**Mathematics Solutions**  
**Statistics Solutions**  
**Financial Solutions**  
**Electrical Engineering Solutions**  
**Surveying Solutions**  
**Games**  
**Navigational Solutions**  
**Civil Engineering Solutions**  
**Mechanical Engineering Solutions**  
**Student Engineering Solutions**



Reorder No. 00029-14010 Printed in U.S.A. 00029-90014

Scan Copyright ©  
The Museum of HP Calculators  
[www.hpmuseum.org](http://www.hpmuseum.org)

Original content used with permission.

Thank you for supporting the Museum of HP  
Calculators by purchasing this Scan!

Please do not make copies of this scan or  
make it available on file sharing services.